cratic to work for hire. They used to grow cotton to an immense extent; but they did not do so now, because they could buy clothing at a much cheaper rate than they could make it for themselves. But they grew three times as much corn as they required for home consumption, and they sold it at a great profit through the medium of Government agents. The Papagos, on the contrary, were fond of hiring themselves out as labourers. At certain seasons they would leave their country—which was very barren and desolate—and hire themselves out for a dollar a day. They would till the ground, work in a mine, or do anything else. Then, when the proper season came round, they would go back to their own country, and cultivate their crops. They had a regular system of government; the head-man was appointed by universal suffrage. They were quite democrats in their notions. They married only one wife: they did not work their women to the extent the wild savages did; in fact, they treated them with a certain amount of respect. He had never known a Papago, a Pima, or a Zuñi Indian, beat his wife. Unfaithfulness on the part of their women was of very rare occurrence and was punished with death. They had flocks and herds in considerable numbers. Horses were scarce among them, because they could only get them from the Americans. Mules they valued very highly, and would give a high price for them—as much corn as would fetch 300 dollars.

2.—*On the Formation of Fjords, Cañons, and Benches.* By ROBERT BROWN, F.R.G.S.

1. FJORDS.—Intersecting the sea-coast of various portions of the world, more particularly in northern latitudes, are deep, narrow, inlets of the sea, surrounded generally by high precipitous cliffs, and varying in length from two or three miles to one hundred or more, variously known as, "inlets," "canals," "fjords," and even on the western shores of Scotland as "lochs." The nature of these inlets is everywhere identical, even though existing in widely distant parts of the world, so much so as to suggest a common origin. On the extreme north-west coast of America they intersect the sea-line of British Columbia to a depth in some cases of upwards of a hundred miles, the soundings in them showing a great depth of water, high precipitous walls on either side, and generally with a valley towards the head. On the eastern shore of the opposite island of Vancouver no such inlets are found, but on the western coast of the same island they are again found in perfection, showing that in all probability Vancouver Island was isolated from the mainland by some throe of nature prior to the formation of the present "canals" on the British Columbia shore, but that the present inlets on the western shore of Vancouver Island formed at a former period the seaboard termination of the mainland, and were dug out under conditions identical with those which subsequently formed the fjords now intersecting the coast.

Jervis Inlet may be taken as the type of nearly all of these inlets

here as well as in other portions of the world. It extends in a northerly direction for more than 40 miles, while its width rarely exceeds 1½ mile, and in some places is even less. It is hemmed in on all sides by mountains of the most rugged and stupendous character, rising from its almost perpendicular shores to a height of from 5000 to 6000 feet. The hardy pine, where no other tree can find soil to sustain life, holds but a feeble and uncertain tenure here, and it is not uncommon to see whole mountain-sides denuded by the blasts of winter or the still more certain destruction of the avalanche which accompanies the thaw of summer. Strikingly grand and magnificent, there is a solemnity in the silence and utter desolation which prevails here during the months of winter—not a native, not a living thing to disturb the solitude; and though in the summer a few miserable Indians may occasionally be met with, and the reverberating echoes of a hundred cataracts disturb the silence, yet the desolation remains and seems inseparable from a scene nature never intended as the abode of man. The depths below almost rival the heights of the mountain summit: bottom is rarely reached under 200 fathoms even close to the shore.* The deep inlets on the Norwegian coast, known as *fjords*, a familiar name now applied generally to such breaks in the coast-line, are too well known to require description. On the coast of Greenland are again found similar sounds, indenting both sides of that island (?), but more particularly the western or Davis Strait shore. Most of these inlets are thickly studded with floating icebergs, and others are so densely choked with them as to receive the names of ice-fjords. All of these fjords form the highways by which the icebergs float out from the glaciers at their heads, whenever these prolongations of the great *Mer de Glace* of Greenland (the "inlands iis") reach the sea. After a long and careful study of these fjords in most parts of the world where they are found, I have come to the conclusion that we must look upon glaciers as the material which hollowed them in such a uniform manner. Everywhere you see marks on the sides of the British Columbian fjords of ice-action, and there seems no reason to doubt but that they were at one time the beds of ancient glaciers, which grinding their outward course to the sea scooped out these inlets of this great and uniform depth. At this present day, not far from the head of most of these inlets, glaciers are found in the Coast range and Cascade Mountains, and along both ranges marks of old glacier-action can be seen 2000 to 3000 feet below their summits, and even near the sea-margin. Such

* 'Vancouver Island Pilot,' p. 139. Richards.

a depression of the coast, with the presence of the lower temperature then prevailing, would fill these fjords with glaciers. I may add that though Prof. Whitney,* on the most hearsay evidence, seems inclined to think that the northern drift is not found over Vancouver Island and British Columbia, it certainly exists in a well developed condition.

2. CAÑONS.—This convenient word, of Hispano-American origin, is used extensively all over the Pacific to express the high perpendicular clefts through which many of the rivers of the west flow often for miles. These cañons are generally found where the river breaks through some mountain range or other obstruction of a like nature on its way to the ocean. Such are the cañons of the Steken in Alaska, the cañons of the Fraser in British Columbia, the "Gorge" of the Columbia or the cañon of the Colorado in Sonora. An examination of these cañons shows them to have been caused by the force of the rivers which flow through them when these rivers contained (as there is every evidence to prove they did at one time) a greater body of water than at present. During the time when these glaciers covered the sides of the Cascade and other ranges adjoining these rivers, a greatly increased amount of precipitation would swell the volume of these streams, enabling them to score so deeply the surface of the plateau, and "force mountain barriers to reach the ocean, cutting deep channels in its shores where we now found them." These rivers seem at one time to have been merely the outlet of great lakes which emptied themselves into the ocean by one or more small rivulets, creeping through the opposing barrier of mountains by rocky gorges or volcanic clefts. Gradually they seem to have enlarged these clefts until a greater body flowed through them. Some of the lesser emptiers were cut off, and joined their volume to the main stream, giving its importance and strength until in the course of ages they graved their record in the huge rocky cañons through which they now flow—the great descendants of the humble outlets by which they once found their way to the country on the other side of the Cascade Mountains and to the Pacific. It appears that many of the rivers of the west have, at one time or another, changed their course and bed. Some of these changes seem to have occurred in very remote times prior to the present arrangement of the superficial formations. At all events the gold-miner now and again comes upon these old river-beds in the course of running his drifting-tunnels or sinking his mining-shafts. They look eagerly for them, as they are generally rich in gold. Other

* Proc. California Academy of Sciences, vol. iii. p. 272.

changes seem to have occurred in very recent times, and seem to have been mainly owing either to the causes I have attempted to portray or to some volcanic action, resulting in throwing the river out of its former course into a new channel. Such is the *grande coule* of the Columbia River well known to all voyageurs. I have spoken of the great cañon of the Colorado River, of which the first published account is contained in the work of Castenada, giving a description of the expedition of Don Francisco Vasquez de Coronado in search of the "Seven Cities of Cibola," in 1540-1, during which time they discovered this river, and named it the *Rio de Tison.* The walls of this cañon are probably 5000 feet in height, and when we consider that the river traverses a magnificent defile of this description for upwards of 200 miles, the effect of the scenery may be imagined. Many years ago, it is said that a party of trappers built a large boat, and made the attempt to descend the river through the defile of the cañon, and were never heard from afterwards; they probably dashed their boat in pieces, and were lost by being precipitated over sunken rocks or high falls. In 1857 Lieutenant Ives, of the United States Army, attempted the exploration of this great gorge with a light-draught steamer, but without success; and in 1865 another attempt was made, but resulted in equally unfruitful results.* Here then is a field where some of those young men who seek athletic laurels in the hackneyed Alps may expend some of their superfluous cash and muscular power, with the additional advantage of probably being likely to add something to our geographical knowledge! An almost equally stupendous cañon is that of the Red River of the south. This cañon shows that these remarkable defiles were not formed by any paroxysmal convulsion of nature, for when a tributary stream enters the main river it passes through a tributary cañon. The action of rivers in forming such gorges as these in geological and modern times is an important but much neglected subject in geology.

3. BENCHES.—On the banks of many rivers of the western slope of the Rocky Mountains are found curious terraced "benches," not unlike in general appearance to the famous "Parallel Roads of Glen Roy," but (without stirring up such debatable ground) altogether different in character. These "benches" are always found to the *east* of the Cascade Mountains, and are well seen at Lilloet on Fraser River in British Columbia. Lord Milton and Dr. Cheadle figure them in their "North-West Passage by Land," as seen at this point. These benches are generally flat and of a good soil, though,

* In August, 1865, I sent a detailed account of this attempt to Sir R. I. Murchison; but it met the fate of many such documents, and never reached him.

as everywhere else to the east of the Cascades, very dry. From what I have already said in reference to the formation of cañons, I need scarcely enter into any long explanation of their origin, as it is at once self-evident, if the explanation I have given of the formation of the clefts just named is correct. In a word, the benches were formed when the Fraser (or other river) was a lake only emptied by some little streams (or stream), now and then gathering strength, and as barrier after barrier was broken down, these benches mark the successive stages of the lowering of the lake's margin until it finally sinks into the channel of the river. I have supposed these breaks to have occurred at intervals as some portion of the wall of the gorge gave way or wore away. This level may have continued for years—it may be centuries—when another break happened, and so on; the height of the "bench" marking the character of the gap made each time. These breaks may have been (indeed no doubt were) assisted by the volcanic disturbances which at a comparatively late period seem to have riven all the country in that region, and volcanoes in the mountains through which these rivers flow were the active agents of disruption. The same "benches" can be seen more or less distinctly wherever the physical contour of the country is the same, or where a river is barred from reaching the sea, under similar conditions to what the Fraser bears to the Cascade Range. That these benches were not connected with glacier action is shown (among other proofs) by the rich character of the soil and the total absence of *moraines*, or other marks of glacier-action. These broadly-marked "benches" ought not to be confounded with some terraces found on various rivers, such as the Columbia, &c., to the west of the Cascades. These terraces are probably connected with glacier-action when the mouth of that river was hollowed for more than a hundred miles of a great and uniform depth. The channel of the Golden Gate (San Francisco) has a maximum depth of nearly 50 fathoms, being greatest immediately in the line of the axis of the chain through which it is cut, while the bar without and the bay within are silted up to within less than 10 fathoms of the surface. The Straits of Carquenes, near the mouth of the Sacramento, have a maximum depth of 18 fathoms, and in the line of the range which bounds them an average depth of 14. Dr. Newberry * thinks that these phenomena are due to glacier-action of a similar character to that which hollowed out the fjords, and on the whole there seems some reason to accept his theory with reservations. On passing down the Columbia from the

* 'Pacific Railroad Surveys,' vol. vi. p. 43.

Dalles to the Cascades a curious feature is seen, which, though scarcely strictly coming under either of the headings of this paper, is yet interesting as helping to explain some of the phenomena of bench and cañon. Under the water can be seen, standing upright and firmly rooted in the soil, the remains of a forest of *Abies Douglasii*, Lindl. General Fremont notices this in his voyage down the river and attributed it to a landslip. This explanation may be easily proved to be erroneous, and must, I think, though generally received without investigation, give way to a totally different one. The vicinity of the Cascade exhibits marks of recent volcanic action, and disturbance of the traps, red scoriæ, &c. The Indians even say that at one time the river used to flow under an archway, but that during an eruption of Mount Adams this bridge was thrown down, forming an island in the centre, and helping to give rise to the "Cascades." The effect of this would be to form a dam in the river, raising its waters above the scene of disturbance, and submerging the forest which grew down to its margin. The very recent date of this submergence is shown by the sound character of the wood. The "bench" is also well figured in the plate of the Cañon of Psuc-see-que Creek (Oregon), in volume vi., p. 85, of the 'Pacific Railroad Surveys.'

This paper will be printed at greater length in the 'Journal,' vol. xxxix.

Mr. E. WHYMPER, in compliance with an invitation from the President to state what he knew of the subjects of the paper, said that he had seen so few of the fjords in Greenland, that he should not like to generalise about them. With regard to those he had visited, it appeared to him true that, at some earlier period, they had been filled by glaciers; but he doubted whether the fjords had been excavated by them. There was nothing to show that any excavation of the sort had occurred. We found in the fjords generally lee sides, that was to say, unworn sides, to the rocks, which would not have been the case if the fjords had been excavated by glaciers.

Dr. BELL wished to impress upon the meeting that there was a great difference between gorges in mountainous regions and true cañons. The true cañon could be formed only in a dry climate, by a river passing over sedimentary rocks, and gradually and slowly eroding its way through them. The cañon was thus a very distinct formation from the chasms and gaps we saw in Switzerland, and other mountain regions. Those might be caused in a variety of ways; but the true cañon was formed by a stream grinding for ages and ages in a dry climate through sedimentary rocks, where there was no heavy rainfall or floods to wash away the sides of the chasm.

Dr. RAE said the fjords he had seen in Greenland all bore marks of ice very high up. Even on the fjord at Frederickshope he distinctly saw the marks of ice, as if a glacier formerly reached the sea there, though now no glacier was given off. The very next fjord to that continued to give off glaciers. He believed these fjords were formed, in great part, by glacial action. The glaciers gradually wore away the rocks, and the action of the streams flowing from the rocks helped to cut them away at the same time. Of the cañons he could not speak, but he could say that Mr. Brown's description of the Fraser River was perfectly accurate.